Past performance and entry in procurement: An experimental investigation

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Reputation and Entry[1]

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*** PRELIMINARY ***

ABSTRACT

This paper reports results from a laboratory experiment designed to explore the relationship between reputation and entry. There is widespread concern among regulators that favoring suppliers which have extensive histories of good past performance, a standard practice in private procurement, may hinder entry by new (smaller or foreign) firms in public procurement markets. While this concern is present on both sides of the Atlantic, EU regulation constrains the use of past performance information in selecting contractors while US regulation encourages it. Our results suggest that while some reputational mechanisms may indeed reduce the frequency of entry besides increasing quality so that the concern is indeed warranted, well-designed reputational mechanisms may increase both entry and quality without increasing the total cost paid by the buyer. Consequently, well-calibrated reputational mechanisms potentially generate large welfare gains for the buyer.

Key-words: Bid preference programs, Bid subsidies, Entry, Feedback mechanisms, Incomplete contracts, Limited enforcement, Incumbency, Multidimensional competition, Participation, Past performance, Procurement, Quality, Relational contracts, Reputation, Vendor Rating

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1. Introduction

Does reputation deter entry? If buyers are allowed to use reputational indicators based on past performance in selecting among sellers, does this necessarily reduce the ability of new sellers—i.e., sellers with no history of past performance—to enter the market? The US Senate's concern that past performance-based selection criteria could hinder small businesses' ability to enter and successfully compete for public contracts recently led to an intriguing but inconclusive report by the General Accountability Office.[3] European regulators appear to have always been convinced that allowing the use of reputational indicators as criteria for selecting among contractors leads to manipulations in favor of local incumbents, hindering cross-border procurement and common market integration. For this reason EU Procurement Directives prohibit taking suppliers' track records into account when comparing their bids and EU regulators continue to resist requests to allow the use of reputational indicators in the bid evaluation process from many European public buyers.[4]

One major reason European public buyers and their national representatives are pushing to permit the use of past-performance indicators in selecting among contractors is that they consider reputational indicators essential to obtain good value for money for the taxpayer. If, however, these indicators deter entry, there may be a trade-off between the improved price/quality ratios buyers can secure using reputational indicators and the decreased ability of new suppliers to enter the market. If the use of past-performance indicators does not deter entry, there is little reason to forbid their use outright and whether to implement reputational mechanisms hinges on whether the resulting increase in quality provision justifies any additional associated welfare costs borne by buyers and sellers.

In this paper we build a simple model of repeated procurement with limited enforcement and potential entry and implement it in the laboratory to shed some light on the questions raised above. We focus on reputation as an incentive system to limit moral hazard in the quality dimension as well as on the effect of reputation on selection through entry. Toward these ends, we assume that some costly-to-produce quality dimension of supply, while verifiable by sellers, cannot be fully specified in a court-enforceable contract. We make the additional assumption that there is a potential entrant firm that is more efficient

[3] (GAO-12-102R, 2011). The inquiry had a qualitative nature and in our reading did not reach clear conclusions.

[4] See the EU Green Book 2011, and the Replies to the Consultation that followed it. The curious thing is that a firm's past performance can be taken into account to decide whether a firm can participate in a call for tender or should be excluded ex ante, which sounds rather inconsistent given that being excluded is a much stronger penalty for a firm that performed poorly in the past than having fewer points from the scoring rule.

than all incumbent firms. In this context, we study how quality, price, entry and welfare change when a simple and transparent reputational mechanism is introduced that rewards an incumbent firm that wins the current auction and provides costly high quality with a bid subsidy in the next procurement auction and that also may award a bid subsidy (of varying size) to an entrant with no history of production.

Reputational mechanisms that reward past performance are an important governance mechanism for private transactions (Bannejee and Duflo 2000). Court-enforced contracts are often not sufficient to achieve a satisfactory governance of the exchange, and since procurement is rarely occasional reputational forces may complement and improve substantially on what formal contracting can achieve. Private buyers, however, are typically only concerned about the price and quality of the good they buy. Regulators in charge of public procurement, instead, are often interested in objectives other than the price/quality ratio of publicly purchased goods. They are usually also concerned that the public procurement process is transparent and open for obvious accountability reasons. The need to prevent favoritism and corruption has led lawmakers around the world to ensure that open and transparent auctions where bidders are treated equally—even when in some crucial dimensions they have very different track records—are used as often as possible.

In public procurement open competition is not only seen as an instrument to achieve efficiency and value for taxpayer money, but also to keep public buyers accountable by limiting their discretion in the allocation of public funds. The fact that limiting discretion to ensure public buyers' accountability could come at the possibly large cost of not allowing reputational forces to complement incomplete procurement contracts was stressed by Kelman (1990), who pushed for a deep reform of the US system when he was the head of public procurement during the Clinton administration. The reform pointed at reducing the rigidity of procurement rules in the Federal Acquisition Regulations and allowing public buyers to adopt more flexible purchasing practices common in the private sector, including giving more weight to suppliers' past performance.[5] Since the Federal Acquisitions Streamlining Act in 1994, US Federal Departments and Agencies are expected to record past contractors' performance evaluations and share them through common platforms for use in future contractor selection.

[5]As in the case of independent central banks, maintaining accountability after an increase in public buyers' ex-ante discretion (independence) requires more stringent ex-post controls in terms of performance measurement and evaluation. A real or perceived lack of stronger ex-post performance controls may be at the root of recent concerns that this process may have led to excessive discretion and poor accountability in US public procurement (e.g. Yukins 2008).

The European Union has instead been moving in the opposite direction. An important concern driving procurement regulation in Europe is helping the process of common market integration by increasing cross-border procurement, i.e., the amount of goods and service each EU state buys from contractors based in other states. The EU Procurement Directives that coordinate public procurement regulation in the various European states considerably limit the use of past-performance information in the process of selecting among offers—a feature that came under broad attack during the 2011 consultation for the revision of the EU Directives.[6,7]

But regulators would also like to ensure that small businesses are not excluded from public procurement, a concern that in the US led to large programs like the Small Business Act, with its rules limiting bundling and establishing the Small Business Agency, and the 'set aside' common in many types of procurement auctions (see e.g. Athey and Levine 2011; Krasnokutskaya, forthcoming). This brings us back to our main research question. It is natural to think that if past performance is important incumbent firms are likely to have an advantage that might deter new entrants. However, in the case of public procurement and of firms' vendor rating systems, we are talking about reputational mechanisms based on public rules, known and accepted by suppliers, like on eBay. Formal mechanisms and rules give commitment power to the buyer and can be designed in quite different ways. A common mistake made by many is to assume that reputational mechanisms must be designed along the line of the eBay feedback system in which new sellers start with "zero reputation"—i.e., on equal footing with an incumbent seller with the worst possible track record. However, a buyer with some commitment power on its rules for information aggregation and diffusion and for selecting suppliers may well award a positive rating to new entrants—e.g. the maximum, or the average rating in the market, which put entrants at less of a disadvantage—and ensure that this is taken into account by the scoring rule that selects the contractor, even if the contractor never interacted with the buyer before. And indeed, private corporations often have vendor rating systems in which all suppliers start off with the same maximal reputational capital—a given number of points—and then lose points when performing poorly. In

[6] See the summary of the replies to the consultation at http://ec.europa.eu/internal_market/consultations/docs/2011/public_procurement/synthesis_document_en.pdf .

[7] Curiously enough, current European regulation acknowledges the importance of reputation for some types of procurement. For example, the European Research Council (ERC) funds top researchers in Europe, selected through peer review, and the track record of the researchers is then the main awarding criterion. ERC funding is distributed almost only on reputation criteria in order to reach the best and the brightest. Other European instruments for the procurement of research, such as the FET-OPEN program, are based on a completely anonymous evaluation instead. On the dedicated homepage of these programs one reads that: "The anonymity policy applied to short proposals has changed and is strictly applied. The part B of a short STREP proposal may not include the name of any organization involved in the consortium nor any other information that could identify an applicant. Furthermore, strictly no bibliographic references are permitted."

many of these systems, points may also be recovered by performing well, but exceeding the initial level of points is impossible. In such quality assurance systems incumbents that have already served the buyer may have lost some of the initial reputational capital while any new entrant would start off with the full initial reputational capital. This type of vendor rating system creates an advantage for new suppliers, stimulating rather than hindering entry, suggesting that it is possible to design a reputational mechanism in public procurement that simultaneously sustains quality and entry.

To verify this conjecture we develop here a simple three-period model of competitive procurement with non-contractible quality provision/investment incorporating the possibility of entry by a more efficient competitor in the third and final period, and implement it in the lab. We incorporate reputation by adding a simple and transparent past-performance based mechanism in the spirit of the vendor rating systems discussed above: past provision of high quality yields an advantage in the current auction. Rather than a point scheme, however, we implement an advantage directly in the form of a bid subsidy. The potential entrant in the third period also has a bid subsidy in some of the treatments. Across treatments, we vary both the existence of a reputational mechanism and, when a reputational mechanism is present, the relative size of the bid subsidy potential entrants enjoy. We use this framework, first and foremost, to ask whether reputation-based procurement must necessarily deter entry. We then dig a bit deeper to investigate precisely how the relative size of the entrant's reputational disadvantage (bid subsidy) affects both the quality level produced by sellers and the total costs paid by the buyer/procurer.

We find that in the absence of a reputational mechanism quality provided is low in all periods, prices are slightly higher than production costs and entry occurs frequently. When a "standard" reputation mechanism is introduced that rewards an incumbent firm for producing high quality in the previous period with a bid subsidy but assigns the lowest possible reputation to new entrants, quality is high, entry declines but the total costs paid by buyers does not change much relative to the no-reputational-mechanism baseline. This result lends credence to concerns about the use of reputational criteria hindering entry. However, we also find that when the reputational mechanism is designed so that entrants, as well as incumbents, are awarded a strictly positive bid subsidy, quality *and* entry increase relative to the case without a reputational mechanism. Moreover, our data suggest that the introduction of a reputational mechanism intensifies competition: contrary to what happens to quality and entry, the total cost paid by the buyer does not increase significantly. This latter pattern suggests that well designed reputational mechanisms may generate large gains for the buyer while, at the same time, maintaining or increasing the rate of entry by more efficient outsiders.

Considered together, our findings suggest there need not be a trade-off between reputation and entry. While our study is admittedly confined to a stylized laboratory setting, if confirmed by further empirical and experimental evidence our results imply that the dual goals of providing incentives for quality provision and increasing entry and cross-border procurement in the EU, or elsewhere, are achievable through an appropriately designed reputational mechanism. Moreover, since the reaction that we observe of prices to the presence of bid subsidies is relatively weak, the increase in quality may come at no cost for the taxpayer.

The remainder of the paper proceeds as follows. In the next section, we discuss closely related literature. In Section 3, we discuss our simple theoretical model and, in the following section, present our experimental design. In Section 5, we present the results from our experiment. The last section provides some concluding remarks.

2. Related literature

Our study is related to a large literature investigating reputation using laboratory or field experiments. One strand of this literature implements games mirroring closely Kreps and Wilson's (1982) chain store paradox game in the lab: a long-run player faces a sequence of short-run players; the long-run player's preferences are his or her private information; this history of long-run players' interactions with short-run players are observable, allowing short-run players to form beliefs about the long-run player's preferences. In this setting, the short run players' equilibrium beliefs *are* the long-run player's reputation. Such beliefs-based reputation can have a beneficial effect for the long-run player, allowing her to earn higher payoffs than possible, in equilibrium, without reputation. Early studies show that experimental participants' behavior fits reasonably well with theoretical predictions, lending credence to the importance and potential benefit of beliefs-based reputation (Camerer and Weigelt, 1988). Subsequent studies investigate more finely both the fit between observed behavior and theoretical predictions as well as the precise mechanisms generating this fit. The results have been mixed (Neral and Ochs 1992; Brandts and Figueras, 2003). For example, Bolton, Katok and Ockenfels (2004) show that reputation can be beneficial for the long-run player even absent uncertainty about her preferences, calling into question the mechanism through which reputation operates. More recently, Grosskopf and Sarin (2010) investigate one alternative mechanism and show that beliefs-based reputational effects are weaker than theory predicts and other-regarding preferences play a non-trivial role. We sidestep the debate about the source and strength of reputation by, differently from this strand of the literature, considering a game with complete and perfect information and implementing a formal reputation mechanism in the form of a bid multiplier.

A more closely related strand of the experimental literature investigates beliefs-based reputation in the specific context of auctions. Dufwenberg and Gneezy (2002) implement 10 periods of first-price sealed bid auctions and vary whether the history of losing bids is observable, finding that when previous losing bids are observable winning bids are higher (i.e., competitive forces are weaker), suggesting reputation between bidders affects efficiency. Brosig and Heinrich (2011) implement two types of auctions, a standard first price auction where the seller with the lowest bid always wins, and another type of auction in which the buyer observes bids and sellers' past histories of quality provision and has complete freedom to choose the winning seller. They find that: sellers invest in reputation by providing high quality when the buyer can choose the winner but not when the buyer has no discretion; buyer discretion therefore increases market efficiency; and that buyers benefit from buyer discretion but sellers do not. Morgan, Orzen, Sefton and Sisak (2010) study how strategic risk and luck affect entrepreneurs' decisions to enter into a market in a repeated competition setting with persistent six-member groups, The role of reputation is minimized by making entry decisions anonymous within groups—in each competition, each entrepreneur observes only how many other group members enter, not which ones. The authors find that when success depends on luck, there is excess entry. Differently from this strand of literature, we implement a formal transparent reputation mechanism not based on beliefs in auctions with complete and perfect information and the possibility of entry. Moreover, our reputation mechanism does not feature buyer discretion.

Reputation has also been studied in the context of exchange platforms where buyers and sellers can leave public feedback about previous interactions. Familiar examples include many popular on-line trading platforms: eBay, Amazon, Cnet, etc. Results have been mixed as to whether this type of reputation mechanism induces more honest behavior or more trade. Bolton et al. (2004) study how such feedback influences honesty and trade in experimental auctions where agents interact repeatedly. They find reputational feedback provides weaker incentives for honest behavior than traditional markets with long-lasting relationships among agents. They argue this is because reputational feedback mechanisms generate a public goods problem: benefits from honest behavior are not fully internalized by the agents. Bolton, et al., (2007) conduct online market games to test how competition and reputation in social networks interact. On the competition dimension they consider three cases: i) no competition (buyers cannot choose with whom they are matched); ii) matching competition (buyers choose sellers on the basis of reputation information); and iii) price competition (buyers choose sellers on the basis of reputation information and price offers by sellers). They consider two types of networks: partners networks (buyer-seller pairs persist) vs. strangers networks (a particular buyer seller interacting at most once). They find that competition in strangers networks increases total gains from trade: with competition and reputation, buyers can discriminate between sellers, creating incentives for seller honesty. Finally, Bolton, et al., (2011) provide experimental evidence on how reciprocity in feedback affects reputation exchange platforms. Modifying the standard feedback system by making conventional feedback blind (simultaneous feedback) and by adding a detailed seller rating system, they find that both of these modifications increase the informational content of feedback but that reciprocity in feedback tends to decrease efficiency. Our paper differs from Bolton et al (2004, 2007, 2011) in that we focus on reputation based on observed quality delivered rather than (possibly false) messages about past quality.

Dulleck et al (2009) study the determinants of efficiency in markets for credence goods varying liability, verifiability, reputation building and competition. Differently from our approach, but similar to much of the literature, reputation in their experimental framework is beliefs-based. They find liability has a crucial effect on efficiency relative to verifiability whereas allowing sellers to build up reputation has little influence. Moreover, competition—consumers' ability to choose among sellers—yields lower prices and maximal trade but not higher efficiency when liability is limited.

On the theoretical side, our work is closely related to the first formal analyses of reputation for quality in the 1980s, including Klein and Leffler (1981), Shapiro (1983), Allen (1984) and Stiglitz (1987), that were directly concerned with the relationship between the ability of reputational forces to curb moral hazard and the competitive conditions prevailing in the market. A central question this literature tried to address is precisely how reputational forces, which require a future rent as reward for good behaviour, could be compatible with free entry. Recent analyses in this direction include Kranton (2003), Bar-Isaac (2005) and Calzolari and Spagnolo (2009), which suggest that when important dimensions of the exchange are not contractible and there are many competing suppliers, limiting entry and competition may indeed be beneficial for the buyer. Hoerner (2002) shows that if prices can be used as signals of quality there are also equilibria in which competition strengthens reputational forces, but this would not be possible in public procurement in which prices are a dimension of the scoring rule selecting the winner and cannot therefore be used to signal quality.

Our work is also related to the literature on the efficient design of "feedback mechanisms" sparked by the emergence of eBay and its well known reputation system, surveyed in Dellarocas (2006). To our knowledge, however, the relationship between the design of the reputation system and entry in a market has not been analysed in this literature.

More indirectly related are theories describing how reputation can be used to deter entry, like the classic studies by Kreps and Wilson (1982) and Milgrom and Roberts (1982), and the recent literature on when reputation may have permanent effects and under which condition it has stronger effects, which is well summarized in Bar-Isaac and Tadelis (2008) and Mailath and Samuelsson (2006).

3. The theoretical framework

The game

We develop a simple game consisting of a sequence of three first-price auctions and three players: two Incumbent firms and one Entrant firm. Only Incumbent firms can participate in the first two auctions. We will refer to the first auction as Auction 1, the second as Auction 2 and the last as Auction 3. Three is the minimum number of stages allowing for both investing in building reputation (in Auction 1) and reaping the gains from such investment (in Auction 2) before entry may occur and the game ends (in Auction 3).

In each auction bids are discrete with 0.01 euro increments and the lowest bid wins. Ties are broken by selecting a winner (uniformly) randomly from among the firms submitting the lowest bid. The winning firm must produce a good but can choose whether to produce a high quality good, which costs the firm c_H, or to produce a low quality good which costs the firm $c_L < c_H$.

While producing high quality is relatively costly, it may yield reputational benefits. We model this in a simple way using a bid subsidy in the form of a bid multiplier that applies for one auction only. Specifically, for $t \in \{2,3\}$, if an Incumbent firm won auction *t-1* and produced high quality in that auction, and then the same firm wins auction *t*, that firm is paid a multiple *B* of its auction *t* bid, with *B*>1. In this way, Incumbent firms that choose to produce high quality today enjoy an advantage in tomorrow's auction, since the minimum bid required to ensure a positive profit is lower for such firms.

Entrant firms cannot participate in the first two auctions but do observe all bids and outcomes. They earn a fixed per-auction reservation wage, *w*. Entrant firms may participate in Auction 3 if they choose to. Specifically, before Auction 3 begins, the Entrant firm decides whether to enter, and forgo *w*, or to stay out of the auction and earn *w*. The entrant firm has a cost advantage in producing low quality, i.e. $c_L^e = c_L - k$, where c_L is the Incumbent firms' (common) cost of producing low quality and *k* is a constant capturing the Entrant firms' higher efficiency.

To investigate the effects of a reputational mechanism on Entrant firms' behaviour, incorporating the idea that such a mechanism may well assign a positive reputational score to a new firm or potential entrant, we assign a bid subsidy, β, to the Entrant firm. We consider three main cases: i) an Entrant firm bid multiplier equal to that of an Incumbent firm with high reputation (β=*B*); ii) an Entrant firm bid multiplier equal to the average of the maximum and minimum possible for Incumbent firms, i.e. $\beta = \frac{B+1}{2}$; and, finally, iii) no bid subsidy for the Entrant (β=*1*). These rules are common knowledge among all players.

Equilibria of the game

We solve this game for the three different levels of the Entrant firm bid multiplier, β, mentioned above and find parameter values allowing for two possible pure strategy equilibria. In a first, "entry-accommodation," equilibrium, the winning Incumbent firm exploits his reputational advantage acquired at the end of the first auction by winning the second auction, receiving his (multiplied) winning bid and then producing low quality. In this way, the incumbent firm accommodates entry in the last period since the more efficient Entrant firm will, in equilibrium, win the last auction producing low quality and making positive profits given its cost advantage.

In a second type of equilibrium — "entry deterrence" — the Incumbent firm who wins Auction 1 keeps its reputational advantage by winning and producing high quality also in Auction 2. Since in Auction 3 an Incumbent firm has a pricing advantage through the bid multiplier, the Entrant firm does not enter.

Obviously, the existence of this equilibrium depends on both the Entrant firm's bid multiplier, *β,* and its efficiency advantage, *k*.

Predictions and Parameter Values

Solving the model, we find restrictions on parameter values yielding the two equilibria mentioned above.

Provided that B $\in \left[\frac{3c_H - c_L}{2c_L}, \frac{c_H + 3c_L}{2c_L}\right]$,

- in the case of an Entrant firm with bid multiplier *β=B,* if $k < w$ only the "entry-accommodation" equilibrium exists;
- in the case of an Entrant firm with no bid subsidy (*β=1),* if $k < \; w + c_L - \frac{c_L}{B}$ only the "entry-deterrence" equilibrium exists;
- in the case of an Entrant firm with bid multiplier $\beta = \frac{B+1}{2}$, if $k = \; w + c_L - c_L \frac{\beta}{B}$ then an Entrant firm is indifferent between entering or not and both the "entry-deterrence" and the "entry-accommodation" equilibria exist.

Given the conditions mentioned above, we chose the following parameter values for our experiment which imply entry deterrence is the unique equilibrium prediction when *β=1*, and that either entry accommodation or entry deterrence are possible when $\beta \in \{\frac{B+1}{2}, B\}$: $w = 1$; $c_L = 1.5$ and $c_H = 2$; $B = 2$; $k = 1.375$. For more details on the model and its solutions, see Section C of the Appendix.

4. Experimental Design

The basic structure

The experiment consisted of four different treatments, which we describe below. In all of the treatments participants played multiple rounds of the game described above, where a complete three-auction sequence constitutes a round. Before each round, participants were randomly and anonymously (re-)divided into groups of three and then randomly assigned one of two roles: two participants in each three-person group were assigned the role of "Incumbent firm," while the third person in each group was assigned the role of "Entrant firm."[8] Within each three-person group, in each round, participants played the sequence of three first-price sealed-bid auctions described above.

Each treatment consisted of from 12 to 15 rounds of the three first-price sealed-bid auctions, with groups being randomly and anonymously re-formed between each round. Participants were instructed that at the end of the experiment one round would be randomly chosen to count toward their experimental earnings.

Within each round, play proceeded as follows. Incumbent firms participated in all three auctions of a round. By contrast, Entrant firms did not participate in the first two auctions, but instead earned a fixed outside wage of 1 euro and observed all bids and outcomes of the first two auctions within their 3-person group. Before the third auction of the round began, Entrant firms decided whether to participate in this last auction and forgo their outside wage, or to stay out of even this last auction and earn their outside wage of 1 euro. Incumbent firms never earned an outside wage in any period.

Within each auction, bids were submitted simultaneously with the lowest bid winning the auction. Ties were broken by randomly choosing among the firms submitting the lowest bid. The winning firm then decided to produce either a low quality good at cost c_L (c_L - k for Entrant firms), or a high quality good at cost $c_H > c_L$. Losing firms earned nothing, while the earnings of winning firms varied by treatment (detailed below). At the end of each auction, participants learned the bids of the other firm(s), and the production decision of the winning firm, in their own three-person groups. Participants never learned anything about choices in groups other than their own. Finally, before the third auction began participants were informed of the entry decision of the Entrant firm in their group.

Four treatments

The basic structure outlined above was common to all sessions. Three treatments involved a formal reputational mechanism. In the fourth, "Baseline," treatment no formal reputational mechanism was implemented. Let us first consider the treatments with a reputational mechanism.

[8] We use the terms "Incumbent" and "Entrant" here for clarity of exposition. Neutral language was used in the experiment. Specifically, roles were referred to as "Firm A" "Firm B" and "Firm C," with the first two being incumbents and the latter the entrant.

The reputational mechanism we implemented took the form of the simple bid multiplier described earlier. For incumbents, this bid multiplier B was the same in all treatments involving reputation. In particular, we set B=2, so that for $t \in \{2,3\}$ an incumbent firm that won Auction *t-1* and produced high quality in that auction and then subsequently also won Auction *t* with winning bid *b*, would be paid 2*b*, so that profits from Auction *t* would be $2b - c$, where $c \in \{c_H, c_L\}$ according to the firm's quality production decision. In Auction 1, no firm received any bid multiplier.

What we varied across the three treatments involving a reputational mechanism was the bid multiplier for Entrant firms: β. In the High Bonus (HB) treatment, we set β = B = 2; in the Medium Bonus (MB) treatment β = 1.5; and in the Low Bonus (LB) treatment Entrant firms enjoyed no bid subsidy, i.e. β = 1. Since Entrant firms participated in (at most) the third auction, their bid multiplier was not contingent on previous production decisions. Specifically, an Entrant firm winning Auction 3 with bid *b* earned $\beta * b - c$, where $c \in \{c_H, c_L - k\}$ according to the Entrant firm's quality production decision.

Baseline treatment

In our baseline treatment, we omitted the bid multiplier for both Incumbent firms and Entrant firms (i.e., β = B = 1). Hence, this baseline treatment involved no (formal) reputational mechanism. Otherwise, the design was identical to the three treatments (HB, MB, LB) detailed above. Winning Incumbent (Entrant) firms earned their bid minus the cost of production, $b - c$, where $c \in \{c_H, c_L\}$ ($c \in \{c_H, c_L - k\}$) depending on the firm's production decision.

[Insert Table 1 about here]

5. Results

All sessions of the experiment were conducted at the Einaudi Institute for Economics and Finance in Rome, Italy, using the software z-tree (Fischbacher, 2007). Twelve sessions were conducted involving a total of 243 participants. Average earnings in the experiment were approximately 12 euro, including payment for an incentivized risk elicitation task after all rounds of the auction game were completed but *before* participants knew which round would be chosen to determine their earnings.[9] Each session lasted about two hours. Information on all four treatments is summarized in Table 1.

Our experimental outcomes of interest are the proportion of winning firms producing high quality, the cost to the buyer, which we call the "buyer's total transfer" to avoid confusion with the producers' costs of producing, as well as the proportion of Entrant firms choosing to enter. In this section, we consider each of these outcomes in isolation and defer to a later section the buyers' welfare which may incorporate all or some of these outcomes simultaneously.

Quality provision

Let us first examine quality provision, as encouraging high quality goods provision is one primary reason buyers might prefer to implement some form of reputational mechanism. In Table 2, we report the average proportion of winning firms providing high quality. We observe a remarkably large increase in high quality provision in the first two auctions in all treatments involving a reputational mechanism relative to the baseline treatment without such a mechanism. For example, in Auction 1 about 80% of winning firms provide high quality whenever there is a reputational mechanism, whereas in the baseline treatment only 18% of winning firms provide high quality – a 340 percent increase in the likelihood of high quality provision! Moreover, pooling over all three auctions, we observe an approximately four-fold increase in high quality provision in any of the treatments involving a reputational mechanism, relative to the baseline treatment. In the Appendix (Table A1), we report a battery of pairwise non-parametric Mann-Whitney tests confirming the statistical significance of many of the large differences observed in the raw numbers: in Auctions 1 and 2, Mann-Whitney tests reveal that quality provision in the baseline treatment is significantly different from all other treatments; differences among the non-baseline treatments themselves are generally not significant.

[9] The risk elicitation task involved a sequence of choices between a sure payment of 5 euro and a lottery involving a 50% chance of a low payoff and a 50% chance of a high payoff. In the lottery, the low payoff was always 2.50 euro while the high payoff increased over the sequence of choices from 7.50 to 17 euro in steps of 50 euro-cents. More risk averse individuals should switch from preferring the sure payment to the lottery later in the sequence, so we take this switch point as an index of each participant's risk aversion. Details on implementation are in the Appendix, Section D.

[Insert Table 2 about here]

A bit more formally, in Table 3 we estimate probit models of the binary decision to provide high quality in each of the auctions separately (columns 1-3). In column 4, we pool observations from all three auctions and estimate a Tobit model using, as the dependent variable, the proportion of the three auctions in which the winning firm provided high quality. In each of these estimates we control for dynamic effects (such as learning) in a simple, transparent, way by including the round of the observation as a control. Additionally, in these and all subsequent model estimates – unless otherwise noted - we cluster standard errors by session to allow for arbitrary within-session correlation of behavior. We find that high quality provision is strongly significantly higher in all of our reputational mechanism treatments relative to the baseline treatment (the excluded category).[10]

Finally, notice that in all treatments except the baseline treatment, quality provision declines precipitously from the second auction to the third auction. This suggests that participants generally understood the strategic incentives associated with the three-auction game, as there is no reputational incentive to produce high quality in Auction 3. At the same time, even in the Auction 3 quality provision is significantly lower in the baseline treatment than in any other treatment. One plausible explanation is that participants acquired a "habit" of quality provision in the first two auctions which carried over to the third auction. In any event, this latter effect is relatively small so we do not focus on it here.

[Insert Table 3 about here]

Entry

Having seen that introducing a reputational mechanism tends to significantly increase high quality provision, the question remains whether there is a trade-off between reputation and entry. In Table 4 we report the proportion of Entrant firms choosing to enter Auction 3. As can already be seen from

[10] In the Appendix (Table B1), we allow for more flexible dynamic effects by introducing a full set of round dummies into our model estimates. Nothing changes either qualitatively or in terms of statistical significance.

these raw data, our results suggest that a reputational mechanism which assigns no bid subsidy to the Entrant firm (LB) may hinder entry. However, at the same time the data suggest that a properly calibrated reputational mechanism which assigns positive reputation to the Entrant firm (MB, HB) tends to increase entry. As a first pass, a battery of pairwise non-parametric tests of entry by treatment is reported in the Appendix (Table A2) supporting the notion that the introduction of a reputational mechanism can either significantly increase or decrease entry, depending on the relative reputational score assigned the Entrant firm.

[Insert Table 4 about here]

To get a more formal sense of the significance of the effect of a reputational mechanism on entry, in Table 5 we report marginal effects from an estimated probit model using as the dependent variable an indicator taking the value one if the Entrant firm decided to enter Auction 3 (and zero otherwise). On the right hand side, we include a set of treatment dummy variables with the baseline treatment as the excluded category. To account for dynamic patterns in a simple way we control for the round of the observation. We find that entry is economically and statistically significantly higher when the Entrant firm is assigned positive reputation (MB, HB) relative to the baseline treatment. In treatments MB and HB the estimated marginal effect of a reputational mechanism is to increase entry by 8 to 10 percentage points. On the other hand, we also find that the decline in entry when the Entrant firm is not assigned positive reputation (LB)—i.e., enjoys no strict bid subsidy—is not statistically significant. As before, we report a specification allowing for more flexible dynamic effects in the Appendix (Table B2), finding similar results.

[Insert Table 5 about here]

Buyer's transfer

Because our results suggest that the effect of reputation on entry depends on the relative level of the Entrant firm's bid subsidy, a natural question to ask is whether the most desirable outcome of high quality coupled with high entry entails a significant cost to the buyer. To avoid confusion with firms' costs of production, in the discussion that follows we refer to the total amount the buyer pays to the winning seller, accounting for any relevant bid subsidy, the "buyer's transfer."

In Table 6 we report average buyers' transfers by treatment and auction, as well as the average buyer's transfer across all three auctions. Our data suggest there is a surprisingly mild effect of even large bid subsidies on buyers' transfers. Buyers' transfers are generally lower in the first auction when there is a reputational mechanism than when there is not, reflecting competition for the bid advantage that reputation entails in the subsequent auction. However, whether considering the second and third auctions individually or focusing on the average buyer's transfer across all three auctions, there is a surprisingly mild effect of our reputational mechanism on buyers' transfers.

[Insert Table 6 about here]

To confirm this appearance, in Table 7 we present OLS estimates of buyers' transfers across treatments and auctions. As usual, we control for dynamic effects in a simple manner here and report in the Appendix (Table B3) estimates allowing for more flexible dynamic patterns. In both specifications we find that introducing a reputational mechanism significantly lowers buyers' transfers in Auction 1 and has little impact on buyers' transfers in Auctions 2 and 3. Considering buyers' transfers averaged over all three auctions, we again find no significant effect of reputation.

[Insert Table 7 about here]

Firms' profits

Taking stock of our results so far, we have seen that our formal reputational system yields the possibility of simultaneously increasing entry and the provision of high quality goods and services without substantially increasing the cost paid by the buyer. Thus, from the buyer's perspective, introducing a reputational mechanism seems to be a panacea. Before investigating this appearance more formally by constructing and estimating a simple welfare function for buyers, let us first briefly consider reputation from a firm's perspective. In particular, what remains to be seen is whether firms fare as well with a reputational mechanism as without in terms of profits. Following our (by now) familiar format, we first present a table of raw data on firms' profits followed by a table of OLS estimates.

In Table 8, we present average firms' profits, where this average includes both Entrant and Incumbent firms' profits. Because Entrant firms earn a "reservation wage," *w*, of one euro in Auctions 1 and 2, and in Auction 3 if they do not enter, we present profits in two ways: including *w* into our profit calculations (left panel); and excluding *w* from the calculations (right panel). Both panels present a similar story: firms' profits are lower in Auction 1 when there is a reputational mechanism than when there is no such mechanism, but higher in subsequent auctions. The patterns in profits are consistent with firms' competing on prices in the first auction for the bid advantage offered by the reputational mechanism in later auctions. Averaging over all three auctions (columns 4 and 8) the impact on firms' profits appears to be relatively mild.

These appearances are confirmed in Table 9 by OLS estimates using firms' profits on the left hand side and our standard set of controls on the right hand side. Estimates permitting more flexible dynamic effects appear, as usual, in the appendix (Table B4). Profits are significantly lower in the first auctions in all treatments, relative to the no-reputation baseline (the excluded category). In Auctions 2 and 3, profits are typically higher but only significantly so in Auction 3 of the High Bonus treatment. Considering the average profit over all three auctions, the data reveal no significant impact of a reputational mechanism on firms' profits. In summary, both the raw data and our OLS estimates suggest that firms are, on average, no worse off with a reputational mechanism than without.

Buyer's preferences: theoretical and empirical welfare functions

As a final exercise before concluding, in this section we construct a welfare function for buyers and examine how buyer's welfare varies, both theoretically and empirically, over our treatments. In particular, we suppose that the buyer derives utility from three additively separable components: buyer's transfer, quality and entry. We model this in a flexible manner by assuming buyer's welfare is simply a weighted average of these three components. We then compare the welfare generated by each of our treatments—both theoretically, using equilibrium predictions, and empirically, using the experimental data—in two cases: i) buyers place equal weight on entry, quality and buyer's transfer;

and ii) the buyer does not care directly about entry at all, but rather divides all weight equally between the remaining two components.

We evaluate buyer's total welfare in each treatment by giving a specific weight to buyer's transfer, quality and entry. The welfare function we consider is $W = \alpha\mathcal{D} + \gamma Q + \delta Pr(E)$, where $\alpha + \delta + \gamma \leq 1$; and $\mathcal{D} = \frac{4.5 - \frac{\sum_{t=1}^{3} T_t^*}{3}}{4.5}$. To make sense of this last expression, notice that T_t is the transfer from buyer to seller (i.e., [winning bid]*[relevant bid multiplier]) in Auction *t*, while 4.5 is the maximum allowable bid in the experiment, so that $\mathcal{D}$ is a measure of the "discount" below the maximum possible price buyers could pay without bid subsidies. The other two components of the welfare function are straightforward: $Q = \frac{\sum_{t=1}^{3} \mathrm{I}[q_H]}{3}$ is the proportion of the three auctions in which high quality is produced; and $Pr(E) = Pr[\mathbb{E}\pi^{entrant} \geq 1]$ is the probability that entry occurs in the last period. Theoretically $Pr(E) \in \left\{0, \frac{1}{2}, 1\right\}$ with the exact value depending on whether the Entrant firm's expected profits are less than, equal to or greater than its reservation wage, *w* = 1. To simplify the analysis, we let $\delta = (1 - \alpha - \gamma)$. [11]

Using the parameters chosen for the experiment, we calculate the buyer's theoretical welfare by computing the equilibrium values of $\mathcal{D}, Q$ and $Pr(E)$ for each treatment and evaluating buyer's welfare in each treatment by for two sets of welfare function weights, α and γ: case i) $\alpha = \gamma = \frac{1}{3}$; and case ii) $\alpha = \gamma = \frac{1}{2}$. We report buyer's theoretical welfare levels in these two cases in Table 10.

[Insert Table 10 about here]

[11] In the MB [B = 2; β = 1.5] and baseline [B = β = 1] treatments, both the entry accommodation equilibrium and the entry deterrence equilibria are possible. In these treatments, we calculate the average expected welfare as $\mathrm{W} = \mathbb{E}(W) = \frac{w(acc)+w(det)}{2}$, where $w(acc)$ is the welfare generated from the entry accommodation equilibrium and $w(det)$ is the welfare generated from the entry deterrence equilibrium. In the other treatments, because we are assuming bids are discrete with bid increment $\varepsilon > 0$, there are (essentially) unique equilibrium predictions.

In case i) where buyers care about entry, quality and transfers equally we find the highest buyer welfare in the HB treatment (when B= β =2, W = 0.710) where the theoretical equilibrium probability of entry is largest. On the other hand, in case ii) where buyers do not care about entry directly, but rather only about quality and transfers, buyer's welfare is maximized in the LB treatment (when B=2 and β =1, W = 0.73) where, even though entry does not occur in equilibrium, its spectre constrains bids and increases quality. In both cases, having a reputational mechanism in place increases buyer's welfare.

Empirically we find a similar result. To calculate empirical welfare, we measure quality, Q, by the average proportion of winning firms providing high quality across all three auctions and across all firms. We measure entry probability, $Pr(E)$, as the average proportion of Entrant firms entering in Auction 3. Finally, as our measure of buyer's transfers we calculate $\mathcal{D}$ according to the formula described above. Table 11 reports our empirical estimates of buyer's welfare.

[Insert Table 11 about here]

For both sets of welfare functions weights we consider, buyers can always achieve higher welfare by implementing a reputational mechanism than by not. Slightly differently from our theoretical analysis, however, buyer's welfare is always maximized in the MB treatment, where Entrant firms are given neither the highest nor lowest possible reputation score. This difference is likely due to Entrant firms basing their entry decisions to a lesser extent on the bid subsidy than theory predicts. For example, entering Auction 3 with probability less than one when their bid-subsidy is relatively high (HB), as we observe in the data, reduces the empirical welfare advantage of HB over MB when buyers care about entry directly.

6. Concluding remarks

In this paper we ask whether the use of reputational indicators based on past performance, while stimulating quality provision, necessarily also hinders entry by new sellers. This is an open, timely and policy-relevant question. In the US, where reputational mechanisms are currently allowed in public procurement, the Senate recently expressed concerns that such past-performance based selection criteria could hinder small businesses' ability to enter and successfully compete for public contracts. On the other hand, in Europe where regulators appear to be sufficiently convinced that allowing the use of reputational indicators as criteria for selecting contractors favors local incumbents over potential entrants to explicitly prohibit the use of reputation in public procurement, public buyers and their national representatives are pushing to allow the use of past-performance indicators in selecting contractors.

We investigated this question experimentally, developing a simple model of repeated procurement competition with limited enforcement on quality and potential entry by a more efficient supplier and implementing it in the laboratory. Treatments differed by the presence and design of a past-performance based reputational mechanism.

First of all, our results show that concerns about reputation hindering entry are justified: naively introducing a "standard" reputational mechanism in which only good past performance is rewarded with a bid subsidy in the following procurement auction increases quality provision but significantly reduces entry.

We then show that properly designed reputational mechanisms in which new entrants, with no history of past performance, are awarded a moderate or high reputation score—as is often done in the private sector, or with point systems in driving licenses—actually foster rather hand hinder entry. At the same time, high quality goods provision is also increased.

Our third important result is that the total cost to buyers (buyer's transfer) does not increase when a reputational mechanism is introduced, even though (costly) quality provision increases. The introduction of bid subsidies for good past performance appears to benefit the buyer/tax payer also by increasing competition for incumbency.

Taken together, our results suggest that there may not be a trade-off between the use of past-performance based reputational mechanisms and entry by new firms into a market. In our experiment a well-calibrated reputational mechanism can increase both entry and quality provision, without increasing the cost for the procurer. Policy makers should probably stop quarrelling about whether a generic past-performance based reputational mechanism should be introduced, and focus on how such a mechanism should be designed in a context where entry has positive social value *per se*.

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Tables and Figures

Table 1: Summary of Treatments

Treatment	Incumbent			Entrant			Participants	Sessions
	Bonus	c_H	c_L	Bonus	c_H	c_L		
HB	2	2	1.5	2	2	0.125	51	3
MB	2	2	1.5	1.5	2	0.125	60	3
LB	2	2	1.5	1	2	0.125	42	2
Baseline	1	2	1.5	1	2	0.125	90	4

Table 2: proportion of winning firms producing high quality

	Auction 1	Auction 2	Auction 3	All Auctions
Baseline	0.18	0.09	0.06	0.11
	(0.047)	(0.034)	(0.035)	(0.037)
Low Bonus (LB)	0.82	0.57	0.14	0.51
	(0.018)	(0.048)	(0.024)	(0.018)
Medium Bonus (MB)	0.77	0.49	0.17	0.48
	(0.010)	(0.075)	(0.026)	(0.031)
High Bonus (HB)	0.78	0.60	0.09	0.49
	(0.04)	(0.025)	(0.040)	(0.018)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Robust standard errors, clustered by session, appear in parentheses. [2] "All Auctions" column reports the n. of times high quality has been produced by the winning firm standardized by the n. of auctions.

Table 3: Quality provision, by auction and treatment

	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	0.51***	0.55***	0.10*	0.73***
	(0.043)	(0.063)	(0.061)	(0.110)
Medium Bonus (MB)	0.53***	0.50***	0.14**	0.69***
	(0.050)	(0.075)	(0.060)	(0.116)
High Bonus (HB)	0.52***	0.58***	0.04	0.69***
	(0.049)	(0.059)	(0.067)	(0.111)
Round	-0.01*	-0.01**	-0.01**	-0.02***
	(0.006)	(0.006)	(0.003)	(0.005)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Columns 1-3 present marginal effects estimates from a (separate) probit model, using as a dependent variable a dummy taking the value one whenever the winning firm produced high quality in the relevant auction (column heading). [2] The fourth column presents results of a tobit regression in which the dependent variable is the n. of times high quality has been produced by the winning firm standardized by the n. of auctions. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table 4: Entry propensity

	Auction 3
Baseline	0.61
	(0.019)
Low Bonus (LB)	0.42
	(0.161)
Medium Bonus (MB)	0.69
	(0.046)
High Bonus (HB)	0.67
	(0.033)
Observations	1,011

Notes: Robust standard errors, clustered by session, appear in parentheses.

Table 5: Entry, by treatment

Low Bonus (LB)	-0.19
	(0.125)
Medium Bonus (MB)	0.10**
	(0.040)
High Bonus (HB)	0.08**
	(0.031)
Round	-0.02***
	(0.006)
Observations	1,011

Notes: [1] Reported values are marginal effects from a probit model, using as a dependent variable a dummy taking the value one whenever the Entrant firm entered Auction 3 rather than staying out. [2] Robust standard errors, clustered by session, appear in parentheses. [3] *** p<0.01, ** p<0.05, * p<0.1

Table 6: Buyer's transfer, by auction and treatments

	Auction 1	Auction 2	Auction 3	Average Over Auctions 1 to 3
Baseline	2.14	1.97	1.57	1.90
	(0.071)	(0.083)	(0.093)	(0.081)
Low Bonus (LB)	1.87	2.02	1.75	1.88
	(0.085)	(0.080)	(0.113)	(0.017)
Medium Bonus (MB)	1.67	1.92	1.62	1.74
	(0.067)	(0.066)	(0.091)	(0.073)
High Bonus (HB)	1.91	1.95	1.82	1.90
	(0.073)	(0.092)	(0.084)	(0.082)
Observations	1,011	1,011	1,011	1,011

Notes: Robust standard errors, clustered by session, appear in parentheses

Table 7: Average buyer's transfer, by auction and treatment

	Auction 1	Auction 2	Auction 3	Average Over Auctions 1 to 3
Low Bonus (LB)	-0.28**	0.05	0.18	-0.02
	(0.111)	(0.116)	(0.147)	(0.083)
Medium Bonus (MB)	-0.46***	-0.03	0.07	-0.14
	(0.103)	(0.114)	(0.141)	(0.117)
High Bonus (HB)	-0.22**	0.00	0.27*	0.02
	(0.101)	(0.120)	(0.123)	(0.113)
Round	-0.02***	-0.04***	-0.04***	-0.03***
	(0.006)	(0.008)	(0.007)	(0.006)
Constant	2.27***	2.21***	1.80***	2.09***
	(0.084)	(0.104)	(0.114)	(0.096)
Observations	1,011	1,011	1,011	1,011
R-squared	0.191	0.040	0.060	0.087

Notes: [1] Each column presents a simple OLS regression using as the dependent variable winning bids in the relevant auction (column heading). [2] Robust standard errors, clustered by session, appear in parentheses. [3] ***p<0.01, **p<0.05, *p<0.1.[4] The dependent variable in this table is the average buyer costs (transfers) over the tree auctions.

Table 8: Firms' profits by auction and treatments, pooling over roles

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Baseline	0.52	0.47	0.31	0.43	0.19	0.14	0.18	0.17
	(0.033)	(0.036)	(0.048)	(0.039)	(0.033)	(0.036)	(0.049)	(0.039)
Low Bonus (LB)	0.32	0.53	0.41	0.42	-0.01	0.20	0.21	0.13
	(0.035)	(0.051)	(0.071)	(0.005)	(0.035)	(0.051)	(0.017)	(0.023)
Medium Bonus (MB)	0.26	0.53	0.34	0.38	-0.07	0.19	0.24	0.12
	(0.028)	(0.029)	(0.038)	(0.029)	(0.028)	(0.029)	(0.034)	(0.028)
High Bonus (HB)	0.34	0.53	0.44	0.43	0.01	0.20	0.33	0.18
	(0.031)	(0.021)	(0.032)	(0.023)	(0.031)	(0.021)	(0.024)	(0.020)

Notes: Robust standard errors, clustered by session, appear in parentheses.

Table 9: Firms' profits by auction and treatment, pooling over roles

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	-0.20***	0.06	0.10	-0.02	-0.20***	0.06	0.04	-0.04
	(0.040)	(0.050)	(0.068)	(0.035)	(0.040)	(0.050)	(0.046)	(0.039)
Medium Bonus (MB)	-0.25***	0.06	0.03	-0.05	-0.25***	0.06	0.07	-0.04
	(0.039)	(0.042)	(0.055)	(0.044)	(0.039)	(0.042)	(0.056)	(0.044)
High Bonus (HB)	-0.18***	0.06	0.13**	0.00	-0.18***	0.06	0.15**	0.01
	(0.040)	(0.037)	(0.052)	(0.040)	(0.040)	(0.037)	(0.051)	(0.039)
Round	-0.01*	-0.01*	-0.01	-0.01**	-0.01*	-0.01*	-0.01***	-0.01**
	(0.002)	(0.004)	(0.004)	(0.003)	(0.002)	(0.004)	(0.004)	(0.003)
Constant	0.55***	0.52***	0.34***	0.47***	0.22***	0.19***	0.26***	0.22***
	(0.035)	(0.042)	(0.051)	(0.041)	(0.035)	(0.042)	(0.051)	(0.041)
Observations	3,033	3,033	3,033	3,033	3,033	3,033	3,033	3,033
R-squared	0.040	0.004	0.006	0.004	0.111	0.005	0.012	0.016

Notes: [1] Each column presents a simple OLS regression using as the dependent variable firms' profits. [2] The first four columns include in this calculation Entrant firms' reservation wage, w = 1, in Auctions 1 and 2. The last four columns exclude the reservation wage from profit calculations . [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table 10: Buyer's theoretical welfare

	Baseline	*LB*	*MB*	*HB*
$\alpha = \gamma = \delta = 1/3$	0.389	0.488	0.599	0.710
$\alpha = \gamma = ½; \delta = 0$	0.333	0.731	0.648	0.565

Notes: [1] Each cell reports buyer's theoretical welfare evaluated according to the model (described in text). [2] In this theoretical welfare function: α is the weight the buyer places on total transfer, expressed as a discount below the maximum possible transfer without bid subsidies; γ is the weight the buyer places on high quality provision; and δ is the weight placed on entry *per se.*

Table 11: Buyer's empirical welfare

	Baseline	*LB*	*MB*	*HB*
$\alpha = \gamma = \delta = 1/3$	0.432	0.505	0.594	0.580
$\alpha = \gamma = ½; \delta = 0$	0.344	0.546	0.547	0.534

Notes: [1] Each cell reports buyer's empirical welfare (described in text) evaluated using our experimental data. [2] In this empirical welfare function: α is the weight the buyer places on total transfer, expressed as a discount below the maximum possible transfer without bid subsidies; γ is the weight the buyer places on high quality provision; and δ is the weight placed on entry *per se.*

Appendix

Section A: Pairwise Mann-Whitney tests

Table A1:Mann-Whitney tests on quality provision

Pairwise comparison	Obs		Auction 1	Auction 2	Auction 3
BA vs LB	360	*z-stat*	-14.118	-11.839	-3.099
	168	*Prob>|z|*	0.000	0.000	0.002
LB vs. MB	168	*z-stat*	1.061	1.601	-0.862
	264	*Prob>|z|*	0.289	0.109	0.389
MB vs. HB	264	*z-stat*	-0.212	-2.319	2.639
	219	*Prob>|z|*	0.832	0.020	0.008
BA vs. MB	360	*z-stat*	-14.897	-11.150	-4.477
	264	*Prob>|z|*	0.000	0.000	0.000
BA vs. HB	360	*z-stat*	-14.393	-13.010	-1.358
	219	*Prob>|z|*	0.000	0.000	0.174
LB vs. HB	168	*z-stat*	0.837	-0.529	1.581
	219	*Prob>|z|*	0.402	0.597	0.114

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A2: Mann-Whitney tests on entry

Pairwise comparison	Obs	Non-par test (z, p)
BA vs LB	360	3.991
	168	0.000
LB vs. MB	168	-5.481
	264	0.000
MB vs. HB	264	0.426
	219	0.670
BA vs. MB	360	-2.086
	264	0.037
BA vs. HB	360	-1.521
	219	0.128
LB vs. HB	168	-4.881
	219	0.000

Notes: Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A3: Mann-Whitney tests on buyers' transfers

Pairwise comparison	Obs		Auction 1	Auction 2	Auction 3
BA vs LB	360	*z-stat*	7.584	3.381	0.072
	168	*Prob>/z/*	0.000	0.001	0.943
LB vs. MB	168	*z-stat*	4.011	0.790	0.445
	264	*Prob>/z/*	0.000	0.429	0.656
MB vs. HB	264	*z-stat*	-5.492	-0.422	-2.290
	219	*Prob>/z/*	0.000	0.673	0.022
BA vs. MB	360	*z-stat*	12.258	5.800	-0.531
	264	*Prob>/z/*	0.000	0.000	0.595
BA vs. HB	360	*z-stat*	7.316	4.120	-2.563
	219	*Prob>/z/*	0.000	0.000	0.010
LB vs. HB	168	*z-stat*	-1.285	0.586	-1.074
	219	*Prob>/z/*	0.199	0.558	0.283

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A4: Mann-Whitney tests on profits, pooling over roles

	Including *w*				Excluding *w*			
Pairwise comparison	Auction 1	Auction 2	Auction 3	All 3 auctions	Auction 1	Auction 2	Auction 3	All 3 auctions
BA vs LB	7.180	-0.518	-2.590	2.234	11.837	2.989	-0.425	5.703
	(0.000)	(0.604)	(0.010)	(0.026)	(0.000)	(0.003)	(0.671)	(0.000)
LB vs. MB	1.307	-0.137	3.111	1.447	2.203	-0.207	0.929	0.162
	(0.191)	(0.891)	(0.002)	(0.148)	(0.028)	(0.836)	(0.353)	(0.871)
MB vs. HB	-1.558	0.384	-1.191	-1.234	-2.274	0.961	-1.002	-1.431
	(0.119)	(0.701)	(0.234)	(0.217)	(0.023)	(0.337)	(0.317)	(0.153)
BA vs. MB	9.396	-0.693	1.103	4.234	15.779	3.273	0.655	6.058
	(0.000)	(0.488)	(0.270)	(0.000)	(0.000)	(0.001)	(0.513)	(0.000)
BA vs. HB	7.686	-0.420	-0.106	2.670	13.035	3.922	-0.277	4.252
	(0.000)	(0.675)	(0.915)	(0.008)	(0.000)	(0.000)	(0.782)	(0.000)
LB vs. HB	-0.171	0.242	1.985	0.463	0.039	0.696	0.126	-0.900
	(0.864)	(0.809)	(0.047)	(0.644)	(0.969)	(0.487)	(0.900)	(0.368)

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment. [2] z-scores from Mann-Whitney tests reported; Prob > |z| appears in parentheses.

Section B: Dynamic trends in our main variables, allowing for non-linear variation

Table B1: Quality Provision

	Auction 1	Auction 2	Auction3	All Auctions
Low Bonus (LB)	0.51***	0.56***	0.10*	0.72***
	(0.045)	(0.065)	(0.061)	(0.109)
Med Bonus (MB)	0.54***	0.52***	0.14**	0.69***
	(0.053)	(0.074)	(0.059)	(0.114)
High Bonus (HB)	0.52***	0.60***	0.04	0.69***
	(0.052)	(0.060)	(0.065)	(0.110)
Period 2 (dummy)	-0.23***	-0.23***	-0.06***	-0.26***
	(0.079)	(0.034)	(0.018)	(0.062)
Period 3 (dummy)	-0.26***	-0.25***	-0.06***	-0.29***
	(0.096)	(0.052)	(0.019)	(0.070)
Period 4 (dummy)	-0.35***	-0.26***	-0.08***	-0.37***
	(0.075)	(0.047)	(0.022)	(0.073)
Period 5 (dummy)	-0.23***	-0.29***	-0.10***	-0.36***
	(0.062)	(0.039)	(0.020)	(0.066)
Period 6 (dummy)	-0.36***	-0.29***	-0.09***	-0.41***
	(0.060)	(0.039)	(0.019)	(0.076)
Period 7 (dummy)	-0.34***	-0.28***	-0.08***	-0.39***
	(0.069)	(0.032)	(0.015)	(0.075)
Period 8 (dummy)	-0.25***	-0.21***	-0.09***	-0.30***
	(0.070)	(0.051)	(0.022)	(0.068)
Period 9 (dummy)	-0.31***	-0.26***	-0.08***	-0.36***
	(0.071)	(0.053)	(0.019)	(0.082)
Period 10 (dummy)	-0.28***	-0.24***	-0.07***	-0.31***
	(0.094)	(0.039)	(0.017)	(0.080)
Period 11 (dummy)	-0.33***	-0.25***	-0.07***	-0.35***
	(0.075)	(0.040)	(0.018)	(0.078)
Period 12 (dummy)	-0.26***	-0.25***	-0.07***	-0.32***
	(0.089)	(0.024)	(0.012)	(0.061)
Period 13 (dummy)	-0.29*	-0.30***	-0.07***	-0.39***
	(0.169)	(0.033)	(0.022)	(0.077)
Period 14 (dummy)	-0.18	-0.30***	-0.09***	-0.37***
	(0.167)	(0.056)	(0.017)	(0.127)
Period 15 (dummy)	-0.42***	-0.33***	-0.09***	-0.58***
	(0.086)	(0.027)	(0.017)	(0.117)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Columns 1-3 present the marginal effects from an estimated probit model using as the dependent variable winning firms' (binary) decision to provide high quality. [2] The fourth column presents results of a tobit regression in which the dependent variable is the n. of times high quality has been produced by the winning firm standardized by the n. of auctions. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table B2: Entry decision

	Auction 3
Low Bonus (LB)	-0.19
	(0.126)
Med Bonus (MB)	0.09**
	(0.044)
High Bonus (HB)	0.07**
	(0.033)
Period 2 (dummy)	-0.13**
	(0.057)
Period 3 (dummy)	-0.17***
	(0.036)
Period 4 (dummy)	-0.15**
	(0.065)
Period 5 (dummy)	-0.27***
	(0.040)
Period 6 (dummy)	-0.25***
	(0.046)
Period 7 (dummy)	-0.24***
	(0.057)
Period 8 (dummy)	-0.34***
	(0.063)
Period 9 (dummy)	-0.33***
	(0.052)
Period 10 (dummy)	-0.31***
	(0.059)
Period 11 (dummy)	-0.35***
	(0.054)
Period 12 (dummy)	-0.34***
	(0.076)
Period 13 (dummy)	-0.15***
	(0.048)
Period 14 (dummy)	-0.25***
	(0.083)
Period 15 (dummy)	-0.49***
	(0.026)
Observations	1,011

Notes: [1] Each column presents the marginal effects from an estimated probit model using as the dependent variable Entrant firms' (binary) decisions to enter Auction 3. [2] Robust standard errors, clustered by session, appear in parentheses. [3] *** p<0.01, ** p<0.05, * p<0.1

Table B3: Buyers' Total Transfers

	Auction 1	Auction 2	Auction3	Average Over All Auctions
Low Bonus (LB)	-0.28**	0.05	0.18	-0.02
	(0.112)	(0.116)	(0.147)	(0.084)
Med Bonus (MB)	-0.47***	-0.04	0.06	-0.15
	(0.098)	(0.109)	(0.139)	(0.113)
High Bonus (HB)	-0.24**	-0.01	0.26*	0.00
	(0.104)	(0.123)	(0.126)	(0.116)
Period 2 (dummy)	-0.23***	-0.35**	-0.28*	-0.29***
	(0.056)	(0.148)	(0.138)	(0.069)
Period 3 (dummy)	-0.43***	-0.52***	-0.42***	-0.46***
	(0.064)	(0.117)	(0.121)	(0.067)
Period 4 (dummy)	-0.43***	-0.61***	-0.48***	-0.51***
	(0.075)	(0.114)	(0.110)	(0.070)
Period 5 (dummy)	-0.45***	-0.59***	-0.56***	-0.53***
	(0.077)	(0.139)	(0.119)	(0.086)
Period 6 (dummy)	-0.42***	-0.57***	-0.50**	-0.50***
	(0.093)	(0.128)	(0.171)	(0.092)
Period 7 (dummy)	-0.44***	-0.67***	-0.52***	-0.54***
	(0.083)	(0.139)	(0.109)	(0.092)
Period 8 (dummy)	-0.42***	-0.58***	-0.51***	-0.51***
	(0.091)	(0.100)	(0.120)	(0.076)
Period 9 (dummy)	-0.40***	-0.70***	-0.54***	-0.55***
	(0.074)	(0.128)	(0.080)	(0.067)
Period 10 (dummy)	-0.45***	-0.72***	-0.61***	-0.59***
	(0.081)	(0.141)	(0.122)	(0.083)
Period 11 (dummy)	-0.43***	-0.61***	-0.56***	-0.53***
	(0.083)	(0.153)	(0.154)	(0.100)
Period 12 (dummy)	-0.47***	-0.67***	-0.63***	-0.59***
	(0.069)	(0.125)	(0.137)	(0.084)
Period 13 (dummy)	-0.30***	-0.57***	-0.74***	-0.54***
	(0.086)	(0.114)	(0.229)	(0.082)
Period 14 (dummy)	-0.35***	-0.80***	-0.69***	-0.62***
	(0.099)	(0.181)	(0.118)	(0.108)
Period 15 (dummy)	-0.38***	-0.59**	-0.42***	-0.46***
	(0.096)	(0.251)	(0.110)	(0.117)
Constant	2.52***	2.52***	2.04***	2.36***
	(0.106)	(0.139)	(0.140)	(0.110)
Observations	1,011	1,011	1,011	1,011
R-squared	0.245	0.076	0.086	0.151

Notes: [1] Columns 1-3 present simple OLS estimates using as the dependent variable buyers' total payments (transfers) to winning firms in auction in the column heading. [2] The fourth column presents a similar OLS estimate, but using average buyers' transfer across all three auctions as the dependent variable. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table B4: Firms' Profits

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	-0.20***	0.06	0.10	-0.02	-0.20***	0.06	0.04	-0.04
	(0.040)	(0.050)	(0.068)	(0.035)	(0.040)	(0.050)	(0.046)	(0.039)
Med Bonus (MB)	-0.26***	0.05	0.03	-0.06	-0.26***	0.05	0.06	-0.05
	(0.037)	(0.040)	(0.055)	(0.042)	(0.037)	(0.040)	(0.055)	(0.042)
High Bonus (HB)	-0.18***	0.05	0.13**	0.00	-0.18***	0.05	0.15**	0.01
	(0.040)	(0.038)	(0.053)	(0.041)	(0.040)	(0.038)	(0.051)	(0.039)
Period 2 (dummy)	-0.05**	-0.02	0.02	-0.02	-0.05**	-0.02	-0.02	-0.03*
	(0.020)	(0.044)	(0.041)	(0.017)	(0.020)	(0.044)	(0.041)	(0.016)
Period 3 (dummy)	-0.12***	-0.11**	-0.06	-0.09***	-0.12***	-0.11**	-0.11**	-0.11***
	(0.021)	(0.037)	(0.038)	(0.021)	(0.021)	(0.037)	(0.035)	(0.020)
Period 4 (dummy)	-0.10***	-0.15***	-0.03	-0.10***	-0.10***	-0.15***	-0.07	-0.11***
	(0.024)	(0.044)	(0.038)	(0.026)	(0.024)	(0.044)	(0.044)	(0.024)
Period 5 (dummy)	-0.13***	-0.16***	-0.09*	-0.12***	-0.13***	-0.16***	-0.16***	-0.15***
	(0.027)	(0.042)	(0.046)	(0.032)	(0.027)	(0.042)	(0.042)	(0.030)
Period 6 (dummy)	-0.10**	-0.14**	-0.09**	-0.11**	-0.10**	-0.14**	-0.16***	-0.13***
	(0.033)	(0.059)	(0.034)	(0.037)	(0.033)	(0.059)	(0.033)	(0.035)
Period 7 (dummy)	-0.11***	-0.13**	-0.06	-0.10**	-0.11***	-0.13**	-0.12**	-0.12***
	(0.032)	(0.052)	(0.051)	(0.035)	(0.032)	(0.052)	(0.050)	(0.037)
Period 8 (dummy)	-0.11***	-0.13**	-0.04	-0.10**	-0.11***	-0.13**	-0.14***	-0.13***
	(0.032)	(0.054)	(0.035)	(0.032)	(0.032)	(0.054)	(0.037)	(0.034)
Period 9 (dummy)	-0.10***	-0.15***	-0.04	-0.10***	-0.10***	-0.15***	-0.14***	-0.13***
	(0.030)	(0.047)	(0.036)	(0.024)	(0.030)	(0.047)	(0.029)	(0.026)
Period 10 (dummy)	-0.12***	-0.15**	-0.03	-0.10**	-0.12***	-0.15**	-0.12**	-0.13***
	(0.033)	(0.055)	(0.050)	(0.034)	(0.033)	(0.055)	(0.056)	(0.039)
Period 11 (dummy)	-0.11***	-0.14**	-0.05	-0.10**	-0.11***	-0.14**	-0.15**	-0.13***
	(0.031)	(0.048)	(0.053)	(0.034)	(0.031)	(0.048)	(0.053)	(0.037)
Period 12 (dummy)	-0.13***	-0.14**	-0.13**	-0.13***	-0.13***	-0.14**	-0.23***	-0.16***
	(0.025)	(0.054)	(0.056)	(0.030)	(0.025)	(0.054)	(0.044)	(0.030)
Period 13 (dummy)	-0.07**	-0.02	-0.05	-0.05	-0.07**	-0.02	-0.09	-0.06
	(0.023)	(0.036)	(0.091)	(0.040)	(0.023)	(0.036)	(0.083)	(0.038)
Period 14 (dummy)	-0.10*	-0.12	-0.15*	-0.12	-0.10*	-0.12	-0.22***	-0.15*
	(0.047)	(0.117)	(0.077)	(0.076)	(0.047)	(0.117)	(0.057)	(0.069)
Period 15 (dummy)	-0.07	-0.10***	-0.01	-0.06**	-0.07	-0.10***	-0.18***	-0.11***
	(0.049)	(0.029)	(0.038)	(0.026)	(0.049)	(0.029)	(0.036)	(0.025)
Constant	0.62***	0.59***	0.36***	0.52***	0.28***	0.26***	0.30***	0.28***
	(0.039)	(0.054)	(0.056)	(0.046)	(0.039)	(0.054)	(0.054)	(0.045)
Observations	3,033	3,033	3,033	3,033	3,033	3,033	3,033	3,033
R-squared	0.042	0.008	0.008	0.008	0.119	0.011	0.015	0.027

Notes: [1] Each column presents a simple OLS regression using as the dependent variable firms' profits. [2] The first four columns include in this calculation Entrant firms' reservation wage, w = 1, in Auctions 1 and 2. The last four columns exclude the reservation wage from profit calculations . [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1